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# BEBR

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The Stock Markets of the Eighteenth Century  
in London and Amsterdam: How Efficient  
Were They?

*Larry Nea!*



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College of Commerce and Business Administration

University of Illinois at Urbana-Champaign

November 1983

The Stock Markets of the Eighteenth Century  
in London and Amsterdam:  
How Efficient Were They?

Larry Neal, Professor  
Department of Economics

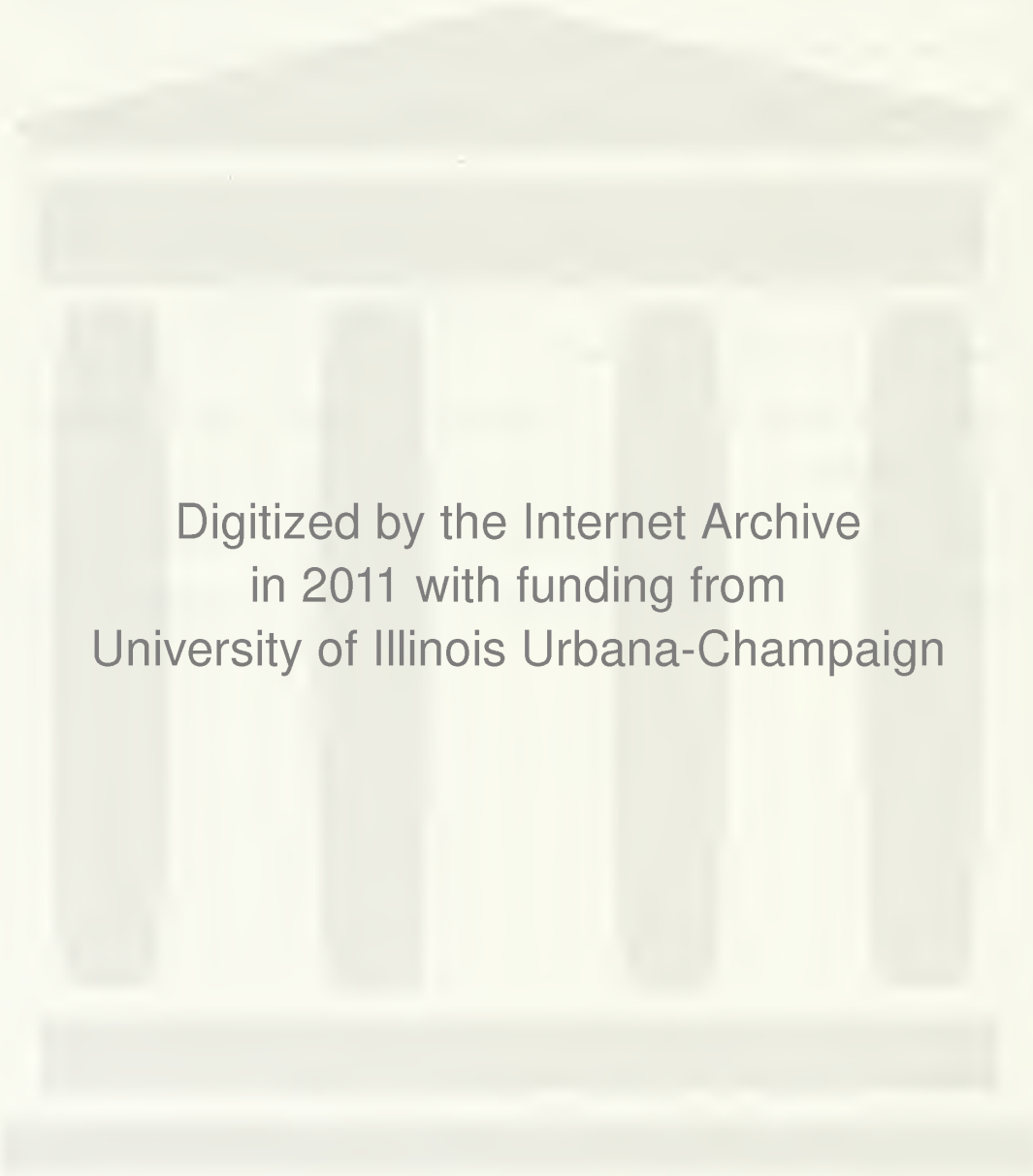
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# ABSTRACT

This paper takes advantage of a rich data source for 18th century financial history--John Castaing's Course of the Exchange. This began publication in 1698 and appeared twice-weekly until 1811 when it became the official stocklist of the London Stock Exchange sold in London. Using the daily stock prices for major English companies and fortnightly stock prices for the same companies in Amsterdam (taken from the Amsterdamsche Courant), three questions are posed and answered. First, why did a separate market arise for English securities in Amsterdam? Second, what explains the differences in prices that did occur between Amsterdam and London? Third, how efficient were these markets, singly and in combination, by comparison with modern markets for financial assets.



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The traditional date for the beginning of the English National Debt is 1693. In that year, Act 4 William and Mary c.3 imposed a special duty on beer, ale, and other liquors to guarantee payment of the interest on a million pound loan which was to be floated at 10% interest. (Carter, 1968, p. 5.) This was the first example of William III applying to his new domain the same techniques for raising credit that he had employed as Stadhouder in the Netherlands. To aid him in raising money for the war against Catholic France, William brought with him numerous financial advisors and military contractors. Daniel Defoe is credited with authoring a piece of doggerel that lamented the preeminence of foreign counsel in William's affairs of state:

We blame the King that he relies too much  
On Strangers, Germans, Huguenots, and Dutch  
And seldom does his just affairs of State  
To English Councillors communicate.  
(Ormrod, 1973, p. 17.)

Indeed, all three of the great joint-stock companies whose shares were to constitute the first part of the perpetual debt of the British government and which were to continue throughout the eighteenth century as the major part of the Funds, had important elements of ownership by foreigners. The Dutch were by far the most important, represented first by Huguenots and then by Sephardic Jews. Far from being suspected as an alien influence on state business, foreigners were actively encouraged to become share-holders. Under the terms of the Tonnage Act of 1694 which established the Bank of England, commissioners were appointed to accept subscriptions from "any person or persons, natives or foreigners, bodies politic or corporate," and the

subscribers were to be incorporated under the title of "Governor and Company of the Bank of England." (Richards, 1934, pp. 204-205.)

From the issue of its General Stock in 1657, the English East India Company had been willing to accept foreign ownership of its stock. However, its unwillingness to enlarge its stock issue during the first decade of William's rule led directly to the formation of the competing New English East India Company. The right of foreigners to hold stock in the United East India Company (formed in 1702) was confirmed in 1730 when an attempt was made to block the sale of certain shares belonging to the leading banking house of Amsterdam, Andrew Pels. The company immediately pointed out "the damage that may arise to the Discredit of the Company's stock if the proprietors should be hindered transferring the same... especially as to merchants abroad who lend money on the credit of it." (Chauduri, p. 446.)

In the original subscription lists for the South Sea Company, founded in 1711, out of the 200 names of private individuals entered, 37 were Dutchmen, Italians, or Jews. (Carswell, p. 57.) Much of the speculative fever that started the rise in south Sea stock in the ill-fated year of 1720 has been attributed to the strong interest shown in Amsterdam. (Wilson, 1941, p. 103.)

The shares of these companies were liquid assets for both English and foreign owners due to the existence of an active resale market for them. The trading activity occurred in the London Stock Market and in the Amsterdam Beurs. The prices at which shares changed owners on the London market are available to us on a daily basis in John Castaing's Course of the Exchange. This remarkable data source began publication



in March 1697 (McCusker, p. 31) and continued to appear twice-weekly, on Tuesdays and Fridays, through the entire eighteenth century under a variety of publishers. In 1811, when it was published by Wetenhall, it was converted into the official price list of the London Stock Exchange. Each issue gave price quotations for the past three days on each of the major securities traded by the brokers in Exchange Alley. These were headed by the shares in the great joint stock companies--the Bank of England, the East India Company, and the South Sea Company.

For the prices on the Amsterdam Beurs, we have available an alternate series of price quotations every two weeks for just the shares of the Bank of England, the East India Company and the South Sea Company. These were published by the Dutch economic historian, J.G. Van Dillen in 1931. Van Dillen took his data from the Amsterdamsche Courant, a Dutch newspaper which appeared fortnightly. Starting July 14, 1723 it began to give price quotes for shares of the Dutch East India and Dutch West India Companies as well as the agio rate for the Bank of Amsterdam. Then in the issue for August 9, 1723, the Courant began giving in addition quotes for the three English joint-stock companies. These continued to appear regularly in each issue, with quotes for other Dutch and English securities coming in for a time and then leaving, until December 19, 1794 when the French occupation of Amsterdam and the founding of the Batavian Republic occurred. The official price list for stocks on the Amsterdam Beurs began publication the following year. (de Vries, 1976.)

This series by Van Dillen reduces the number of our observations for each of the English companies from over 30,000 to only 1,676. For each date in the Amsterdam series, I took the London quotation for each company on the same trading day, producing six time series each with 1,676 observations.<sup>1</sup> Graphing both the levels and first differences of the prices in each market against each other for each company makes it evident that the two markets were very closely correlated from the beginning of the series. Unfortunately, these graphs are far too long to reproduce here. However, Table 1 gives the correlation coefficients between the first differences of the natural logarithms of the price series in Amsterdam and London for the Bank of England and the East India Company. These correlation coefficients are quite consistent across the four peacetime periods that occurred between 1723 and 1794.<sup>2</sup> And they are consistently high for each of

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<sup>1</sup>This exercise was complicated by two features: 1) the Dutch had been on the Gregorian calendar since the middle/end of December 1582 while the British did not shift until September 2/13, 1752; and 2) the Amsterdam market traded Sunday through Friday while the London market traded Monday through Saturday. To deal with the first feature, I counted back eleven days to find the corresponding London quotes before September 13, 1752; the second feature was dealt with by matching the Saturday quote in London to a Sunday quote in Amsterdam whenever one appeared.

<sup>2</sup>From Keller's Dictionary of Dates (1934), I chose October 19, 1739 as the start of the first war period (War of Jenkins Ear) and October 1748 as the end (Treaty of Aix-la-Chapelle). Hostilities began for the Seven Years War in August 1756 while for financial purposes in the capitals they ended with the Treaty of Paris signed February 10, 1763. I took March 13, 1778 as the effective date of hostilities in Europe arising from the American War for Independence since this was when the Treaty of Alliance of France and the United States was communicated to England. This ends with the Preliminary Treaty with the United States signed in Paris on November 30, 1782.

Table 1

Correlation Coefficients between London and Amsterdam  
Prices for Stock of Bank of England and East India Company  
for 1723-1794 and Various Sub-periods of War and Peace.  
(first differences of natural logarithms)

Period	Bank of England	East India Company
1723-1794	0.994	.993
Peace		
8/23 - 10/19/39	0.966	0.979
10/48 - 8/15/56	0.949	0.977
2/10/63 - 3/13/78	0.966	0.979
11/30/82 - 12/30/94	0.969	0.980
War		
10/19/39 - 10/48	0.961	0.980
8/56 - 2/10/63	0.911	0.957
3/13/78 - 11/30/82	0.896	0.940

the three companies. One's first question upon finding two distinct price series for the same financial asset--were the two markets in which prices were struck closely integrated?--is answered here with a resounding affirmative. There remain, however, several interesting questions lurking behind this evidence of market integration.

The first question is historical. Why would there arise a separate market for English securities in the Amsterdam stock exchange? The second question is both economic and historic. What explains the pattern of differences in prices that do occur between Amsterdam and London? The third question, and the last one that can be treated in this paper, is strictly economic. How efficient were these two markets, singly and in combination, by comparison with modern markets for financial assets, due allowance being made for the slower pace of communication and of trading activity in the eighteenth century?

## I

The first question has been treated in the literature only fitfully and it may be useful to draw together some of the separate threads of the story that have been woven to date. Each of the three companies made explicit provision in their charters for the sale of shares to foreigners. And this right of foreigners to hold shares even in these quasi-governmental organizations was reaffirmed on several occasions in the course of the eighteenth century. Especially important as foreign investors were the Dutch. Their major involvement in English public finance begins with the accession to the throne of England by William III at the end of 1688. Van Dillen (1940, p.



584) gives a few of the more noteworthy examples. Moses Machado went with the king to England in 1688 and became his prime contractor for the campaign in Ireland; Joseph de Medina had a large contract as military supplier in 1713; while Sir Solomon de Medina was the greatest army contractor of his day, financing in particular the campaigns of the Duke of Marlborough.

How large were these investments by the Dutch in the English public debt? The question was of sufficient political importance in 1776 that Lord North reputedly had his staff determine the precise extent of Dutch involvement at that date. Their figure, over 41 percent, was effectively challenged by Alice Carter. (Carter, 1953a-c.) Indeed, she even cast doubts that such a study was ever done. Her independent estimate of the Dutch share in 1776 reduced the traditional figure to 25 percent. This was still at the high water mark for the century according to her and by 1789 the Dutch were disinvesting rapidly. (Carter, 1959, p. 442.) Her analysis of the transfers of Bank stock in the three month period, January 1 to March 31, 1755, shows that 59 of the 379 buyers (or 15.6%) in that interval were residents of the Netherlands. And in the fourth distribution of dividends to Bank shareholders in 1697, Carter found that nearly one-tenth were distributed to Huguenots who had fled from France after 1680, while Huguenots held 14% of the stock of the Million Bank. (Carter, 1975, pp. 83-90.)

In the most recent summary of the available studies, Wilson finds that in 1723-24 the total foreign holdings of stock in our "Big Three" companies amounted to 9.3 percent of the total capital. (Wilson,

1980, p. 199.) By 1750 the total of foreign holdings in the same companies (by now South Sea annuities had replaced the original stock) amounted to 19.2 percent. (p. 201.)

The more interesting questions of the ebb and flow of Dutch investments in the English securities, particularly whether they were destabilizing and speculative as contemporary English opinion had it, or whether they were passive and on the whole stabilizing as both Carter and Wilson believe, remain unanswered by their researches into the archives of the English companies and the notarial archives of Amsterdam. Indeed, Wilson argued in his 1959 comment on Carter's findings that these questions could never be answered from the Dutch evidence in probate records concerning the payments made of the Dutch Collateral Succession Tax. Carter agreed but argued that the transfer records of shares in the Bank of England and East India Company archives would provide exactly the kind of evidence Wilson was seeking. Only the transfer books for the Bank of England, however, provide the kind of evidence capable of linking foreign movements of capital to sustained rises or falls in the market price of British company shares. (Carter, 1955, p. 203.) To date the only use of these records has been by Carter and then for only a three month period at the beginning of 1755. (Carter, 1955.) The best that can be done for the other stocks is to search for evidence that either of the markets for English securities, the Amsterdam and the London stock exchanges, were less than efficient in setting prices.

The first official mention of a stock market in London comes under a law passed in the reign of William III, statute 8 and 9 William III,

cap. 32. This provided for the licensing of stock brokers in the city of London, the number not to exceed 100, and for each broker to wear a silver medallion having the king's arms on one side and the arms of the city of London with his own name on the other. This was to be produced at the conclusion of every bargain. In 1720, the Bubble Act (6 Geo. 1, cap. 18) limited the raising of stocks and trading in them to those companies granted charters by Parliament. In 1734, Barnard's Act (7 Geo. II, cap. 8) forbade all dealings in options and future deliveries of stocks, with a fine of 500 pounds to be levied on each person party to such a contract. (Postlethwayt, "Stock-jobbing".)

This latter act was persistently violated in fact, according to Mortimer (1761). Nevertheless, the various price lists that have been examined by Cope (1978) show prices either for money or for the date at which the transfer books for the given security were to be opened. Castaing's was consistent in showing prices at money although the curious practice of printing the names of the Bank of England and the East India Company in capital letters may have developed to indicate those securities in which dealings in time may have been possible. (Cope, p. 18.) It is not until 1783 that a publication, Prince's Price Current, gave both prices for money and for time, but even then only for 3 percent Consols, the most speculative stocks in that period. (Cope, p. 20.) This coincides with the hostilities of the Fourth Anglo-Dutch War which helped complete the withdrawal of Dutch investments from the English funds. (Cf. Riley, 1980.) The illegality of dealings in futures and options may not have eliminated the practice in the London market--indeed, the introduction of stiffer

bills in the House of Commons in 1745, 1756, 1771, and 1773 may indicate the continued prevalence of futures trading--but it no doubt was effective in eliminating the printed quotation of future prices for those contracts that were made.

In Amsterdam, by contrast, the practice was always to deal in time contracts since legally binding possession of shares in the Dutch East India Company was not possible until the actual transfer of the share or shares was entered in the Company's books. De la Vega's original description of the Amsterdam Beurs in fact describes "putts" and "refuses" in very modern terms for options trading. The extensive trading of dealers with one another on both hedging and speculative contracts in the same stock required regular "rescounter" settlement dates to settle the net differences and straighten out the accounts among the various brokers. These occurred quarterly, on the fifteenth of February, May, August, and November. (de Pinto, p. 305.) The quarterly rescounters may have been for the English funds only, since de la Vega reports monthly rescounters, on the 20th of the month for real stock with payment due the 25th, and on the first of the month for "ducaton" shares. (de la Vega, introd. by Kellenbenz, p. xviii.)

Van Dillen notes the difficulties in deciding whether the figures in the Amsterdamsche Courant were cash or time prices:

Until 1747 this is not mentioned, but in comparing them with those found in brokers' notes preserved from 1725 to 1737 it appears that in that period the quotations are cash prices. In the year 1737 both prices are sometimes mentioned. After this year we find generally the forward rates. From 1759 onwards the quotations are often followed by the name of the next settlement month, e.g., "all of February." The difference between the cash price and the next paying month is, however, not more than a few percent. (Van Dillen, p. 13.)

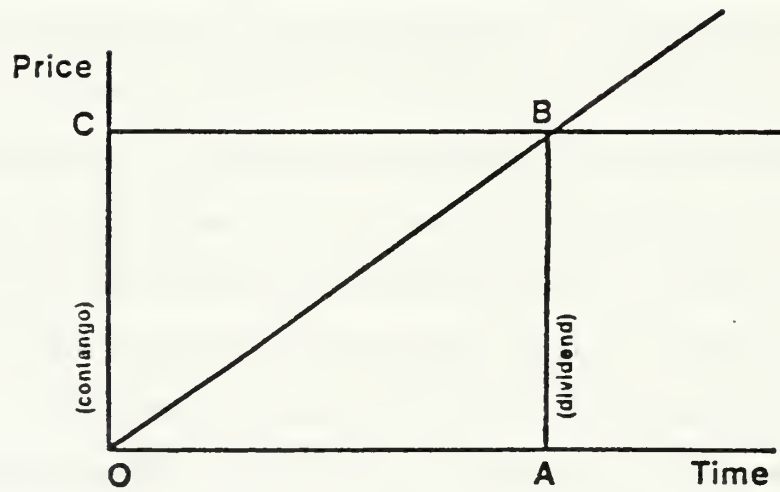


If the Amsterdam prices quoted on the English securities were for future delivery, then in general they should lie above the London cash prices quoted on the same day. The following section of the paper explains why this should be so and presents the results of two tests determining if the quotations for the same securities at the same time on the Amsterdam and London markets are really future prices and spot prices.

## II

Chart 1 is taken from the work of Louis Bachelier whose doctoral dissertation, "La Theorie de la Speculation" in 1900 is regarded as the first work to use modern probability theory to analyze the movement of stock market prices. At regular intervals, dividends are paid on each of our securities. If nothing else happened to disturb the price of the shares from time 0 to time A on the graph, the nominal value of each share would be fixed until the dividend was paid, at which time the value would rise abruptly. Cash transactions in the shares between time 0 and time A will take into account the forthcoming dividend payment which the buyer of the share will receive. So the cash prices between time 0 and time A will show a gradual upward trend along line OB. A contract made at time 0 for future delivery of the share at time A, however, will require the buyer to pay a "contango" to the seller, equal in the absence of disturbances in the price of the share to the dividend. This arises since the seller will hold the share until the delivery date but will then yield possession of the stock, and its dividend, to the buyer who only then will make

Chart 1  
Equivalent Prices of Spot and Future Deliveries



full payment. This means that the futures price equivalent for the cash price that runs along line OB will be line CB, which always lies above the cash price but gradually converges to it at dividend payment dates.

If Bachelier's exposition explains as well the differences between Amsterdam and London prices, then the Amsterdam prices should be the same as the London prices with only small random disturbances until Barnard's Act in 1734 or until 1737 when Barnard's Act was made a perpetual law. Thereafter, the expected level of Amsterdam prices should be above London prices. Table 2 shows the results from comparing Amsterdam and London prices for each of the three securities within two sub-periods, August 1723 to December 1737 and January 1738 to December 1794. The distribution of price differences makes it clear that in the first period the chances were essentially the same for the Amsterdam price to be the higher of the two as for the London price. In the period 1738 to 1794, by contrast, the chances were over three out of four that the higher price would occur in Amsterdam. Moreover, the higher price in London, when it did occur, would be most likely less than one point higher than the price in Amsterdam. The higher prices in Amsterdam, by contrast, would lie one to three points above the London prices.

This evidence certainly points in favor of our hypothesis; is it possible to be more rigorous? Table 3 presents regression results for the simple linear regression of the difference between the Amsterdam and London price at a given date on the number of days from that date to the payment of the next dividend. Only the Bank of England and

Table 2

Comparison of Amsterdam and London Security Prices for the  
Sub-periods 1723-1737 and 1738-1794

Panel A. 1723-1737

Number of times price was higher in:

	London				Amsterdam		
3 or >	1 to 3	0 to 1		0 to 1	1 to 3	3 or >	

Bank of England

15	72	63		66	60	43
	Total = 150				Total = 169	

East India Company

44	88	47		36	45	69
	Total = 179				Total = 150	

South Sea Company

17	59	82		92	51	33
	Total = 158				Total = 176	

Panel B. 1738-1794

Bank of England

12	79	183		322	447	219
	Total = 274				Total = 988	

East India Company

52	123	128		186	373	417
	Total = 303				Total = 976	

South Sea Company

15	89	181		327	508	128
	Total = 285				Total = 963	



Table 3

Regression Results for Le Bachelier Model  
of Amsterdam-London Price Differences

$$P_A - P_L = B_0 + B_1 (\text{No. of Days to Next Dividend})$$

<u>Stock</u>	<u>Time Period</u>	<u>B<sub>0</sub></u>	<u>B<sub>1</sub></u>	<u>R<sup>2</sup></u>	<u>D/W</u>
Bank of England	1723-1737	-0.84 (-3.55)	0.014 (7.33)	.28	1.92
	1738-1794	-0.13 (-1.16)	0.015 (15.20)	.23	2.02
	1748-1756	-0.15 (-0.69)	0.011 (5.63)	.18	2.02
	1763-1778	-0.36 (-2.22)	0.017 (11.69)	.34	2.04
	1782-1792	-0.24 (-0.69)	0.019 (6.02)	.19	1.99
East India Company	1723-1737	-0.90 (-3.41)	0.013 (5.37)	.09	2.01
	1738-1794	0.01 (0.08)	0.020 (13.05)	.17	2.05
	1748-1756	-0.32 (-1.04)	0.022 (7.51)	.27	2.05
	1763-1778	0.16 (0.42)	0.023 (6.71)	.19	2.09
	1782-1792	0.36 (1.11)	0.021 (6.63)	.16	1.77

Notes: t-statistics are shown in parentheses. R<sup>2</sup> is adjusted for degrees of freedom. Equations with D/W in range of 1.9-2.0 have been adjusted with Cochrane-Orcutt procedure.

East India Company stocks are analyzed since the South Sea Company stock was essentially dormant for most of the period after 1730. The results are adjusted for autocorrelation using the Cochrane-Orcutt procedure. They also give supporting evidence for the hypothesis.

Only in the pre-Barnard Act period does the constant term in the regressions become statistically different from zero, and it does so for both the Bank of England and the East India Company. For the entire period 1738-1794 and for the three peace-time periods within, the constant terms are insignificantly different from zero. This implies both that the contango rate was on average the same as the dividend rate, which we should expect in the absence of persistent expectations for things to improve or to deteriorate, and that no serious barriers existed to equalizing the rate of return on the same financial assets in the two different countries.

The presence of a significantly different from zero constant term that is negative in the pre-Barnard Act period could imply segmented capital markets or exuberant outlooks by speculators, but only if in fact the Amsterdam prices are forward prices consistently. More likely they are not and the regression line is forced down by the recurrence of cash prices. It is interesting that on average the Amsterdam price was higher than the London price even in the period 1723-37, although the difference was much less than it became after 1737. This holds for both stocks.

There remain differences between the regression estimates for the Bank of England stock and the East India Company stock. On average, the price difference was 1.6 points for Bank stock and 2.5 points for

East India stock. This reflects the generally higher dividend rates paid by the East Company stock. The higher coefficient for  $B_1$  in the East India Company regressions reflects this fact. The gradual rise in the  $B_1$  coefficient over the 1738-1794 period for the Bank of England regressions is a mystery, especially in light of the nearly constant level of the  $B_1$  coefficient in the East India Company regressions. Finally, it may be noted that by far the highest  $R^2$  is reached for each stock in the period 1748-1756. This may be because our peacetime period is more clearly and unambiguously defined for these years, but it may also be because the commercial and financial relations between England and Holland were less troubled by legislative interference, financial disruptions, and political stresses in this period than in the later peacetime periods.

In sum, these regression results, combined with the evidence of extremely tight market integration presented in the introduction, demonstrate that what small, but persistent differences in prices remained between the Amsterdam and London markets for the British securities were due to the London prices being cash, or spot, prices while the Amsterdam prices were, at least after 1737, forward prices. This finding permits us to ask some of the same kinds of economic questions about the efficiency of the two markets, cash and forward, that are posed in the current literature.

### III

Table 4 gives the initial results of time series analysis on the four main time series of interest--the cash prices for Bank of England

and East India Company stock quoted in London, and the forward prices for the same two stocks quoted in Amsterdam. Basically, we are interested in testing the proposition that the following equations are accurate descriptions of price movements in each case:

$$1) \quad P_{t+1}^i - P_t^i = u_{t+1}; \quad i = 1,3; \quad t = \text{time}$$

$$2) \quad Q_{t+1}^i - Q_t^i = u_{t+1}; \quad i = 1,3; \quad t = \text{time}$$

where P is the cash price and Q is the forward price.

Using the straightforward method of Ordinary Least Squares regressions to estimate these equations, we would hope that in regressing current P or Q upon the lagged value of P or Q that the constant term would be zero and the estimated coefficient upon the lagged value would be one. This would mean that a speculator interested in making money by predicting correctly price swings in these markets, without bothering to learn anything about underlying movements in the determinants of supply and demand of the traded items, would be stymied. The best prediction he could make would be that the next period price would be the same as the last period price plus or minus a random disturbance.

In fact, such regressions perform quite well, but they are not presented here since they are biased to support this outcome, the more so the longer the time series in question. Since these are very long time series, they perform very well indeed in these regressions. This is so since the longer the time series, the closer one comes to regressing a given time series simply on itself. What then becomes of

interest is to see what kind of pattern emerges, if any, in the residuals of such a regression equation. However, given the length of the time series, the Durbin-Watson statistic becomes more likely to indicate insignificant serial correlation even when runs of deviations above or below the previous price occur regularly with enough duration that knowledgeable speculators could make money. Our observations are separated by, on average, two weeks which is certainly long enough even in the eighteenth century to get information, make a trade, and observe the effect on price of the trade.

A superior technique is to estimate so-called AutoRegressive, Integrated, Moving Average (ARIMA) models for the changes in prices. If it can be found that some combination of autogressive and moving average processes yield consistently good descriptions of price changes, then presumably these processes could be discovered by interested speculators and used to make profits in the markets. The results of two different techniques for estimating ARMA models are shown in Table 4. For efficient markets to have existed, these models should show (0,0)--i.e., that last period's price alone remains the best predictor of this period's price.

Both the "Uni" and the "APARMA" methods are strictly mechanical procedures that estimate the autocorrelation coefficients and the partial correlation coefficients for up to 10 lags over the time series. The "Uni", or standard Box-Jenkins method, determines which of these coefficients are statistically significant from zero and then the investigator selects the most plausible model. (Box and Jenkins, 1970.) The APARMA method is a recursive process in which each auto-



Table 4

Estimated ARMA Models  
for Bank of England and East India Company  
Stock Price Changes in London and Amsterdam

Bank of England

Time Period	London		Amsterdam	
	Uni	APARMA	Uni	APARMA
1723-1794	0,0	0,0	0,0	0,0
1723-1737	0,0	0,0	0,0	0,0
1738-1794	0,0	0,0	0,0	0,0
1748-1756	0,2	0,0	0,1	0,0
1763-1778	2,0	2,0	0,0	0,1
1782-1792	0,0	0,0	0,0	0,0
1739-1748	3,0	3,0	0,0	0,0
1756-1763	0,0	0,0	0,0	0,0
1778-1782	0,0	0,0	0,1	1,0

East India Company

1723-1794	0,0	0,0	0,3	0,3
1723-1737	0,0	0,0	2,0	0,0
1738-1794	0,0	0,0	3,0	3,0
1748-1756	0,0	0,1	0,0	0,2
1763-1778	0,0	0,0	3,0	0,0
1782-1792	0,0	0,0	0,1	0,1
1739-1748	0,0	0,0	0,3	0,3
1756-1763	0,0	0,0	0,0	0,0
1778-1782	0,0	0,0	0,1	0,1

regressive process up to order 10 is estimated and then the residuals of each estimate are used to calculate variances. The process which minimizes the expression:

$$\log \sigma_k^2 + 2k/n,$$

where  $k$  is the order of autoregressive process and  $n$  is the number of observations. Then by least squares, ARMA models are estimated up to order  $(p,5)$  where  $p$  is the order of AR model selected above. Finally, the residuals of the estimated ARMA models are used to calculate sample variances and  $(p,q)$  selected which minimizes:

$$\log(\sigma_{p,q}^2) + ((\log n)/n)(p + q)$$

where  $q$  is the order of moving average process. (Hannan and Rissanen, 1983.) The tests are repeated for various subperiods, corresponding to the peacetime and wartime periods selected above.

For the period as a whole, both methods are consistent in showing market efficiency in both markets for Bank of England stock and in the London market for East India Company stock. Both methods indicate that a  $(0,3)$ , i.e., a third-order moving-average process, existed in the Amsterdam prices of the East India Company. This appears to be in place only after 1737, however. Only in the London market for East India stock do we find consistent evidence in each sub-period that an efficient market was maintained. In the two markets for Bank of England stock we find sub-periods when some kind of ARMA process seems to have been at work. It is interesting, however, that these never occur in both markets for any given sub-period. The implied 6 weeks

lag in price determination of East India Company stock on the Amsterdam exchange may reflect rescontre dates, which while normally every 3 months for the English stocks may have been shortened by half for the more active stock. (Cope mentions the emergence of 6 weeks rescontre dates on the London Stock Exchange in 1758.) (Cope, p. 16.) The failure of a similar pattern to emerge in Bank of England stock may be due to less speculative investing in this stock, particularly by the Dutch. (Carter found that Bank of England stock was owned only in very large amounts by Dutch investors.) (Carter, 1953c.)

To reach a preliminary conclusion, efficient markets for the leading British financial securities appear to be in place in both Amsterdam and London immediately after the South Sea Bubble of 1720. Moreover, they seem to have continued to operate efficiently up to the outbreak of the French Revolutionary Wars at the end of the century. Various episodes of market inefficiencies leading to speculative profit possibilities probably did arise at times when the political relationships between England and Holland altered. These periods merit closer examination by financial historians of both countries, as well as more refined tests of the efficient markets hypothesis by economists. The results should prove informative to both historians and economists.

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